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Economically Important Invasive Weed: The Geographical Distribution, Impacts and Management Practices of *Parthenium hystrophorus* L. in Ethiopia

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Abstract: **Parthenium weed is an annual herb in the family Asteraceae which is characterized by deep tap root, pale green leaves and an erect stem that becomes woody gradually.The aim of this review was to identify the distribution,impacts and the possible management practices against Parthenium hystrophorus L.in Ethiopia.Parthenium hystrophorusL.is one of the invasive weed species invading the natural ecosystem in Ethiopia as well as many countries of the world.The weed can tolerate wide ecological range;occur in diverse habitats,on wide range of soils and grow throughout the year provided adequate moisture,temperature and sunlight are available.A large area in Ethiopia has also been invaded and invasions by these weed are expected to change the natural diversity and balance of ecological communities in the country.Before encroaching onto native vegetation, these aggressive environmental weed generally takeover disturbed areas.Thus the survival of many indigenous plants may be threatened. Apart from this these alien weed species can disrupt waterways,produce allergies,adversely affect human and animal health,livestock production and reduce aesthetic values.This weed is capable of displacing other desirable plant species in many habitats and had impacts forests due to its allopathic effects which can reduce germination of neighboring plants.Its establishment in pasture and grazing landcompetesthe valuable plant species for livestock. Parthenium can cause heavy yield reductions in many crops.Therefore,these weed is increasingly seen as a threat not only to biodiversity and ecosystem services, but also hazard to human and animal health.Mechanical,physical,chemical,cultural methods and biological control methods were the most commonlypractices in Ethiopia.Zygogrammabicolorata and *Listronotussetosipennis* most commonly used bio control agents in Ethiopia that were reared under green house at Ambo plant protection research center but Zygogrammabicolorata was released to naturally infested field at Eastern part of the country.Therefore,sustainable long term management strategies should include prevention, use of replacement competitive plants in newly infested and insect bio-agents in severely infested areas. In grazing and pasturelands as well as in low infested forests and non-crop areas, integrated use of herbicides as well as rehabilitation with useful plant species has to be developed. To contain the further spread and soil seed bank buildup for future infestation these weeds should be utilized for mulching, composting, residue incorporation in crop fields and production of biogas etc. Besides,extensive mass awareness and community campaign especially to uproot Parthenium and its safe disposal among the stakeholders needs be conducted.**

Keywords: **Control,impact,Parthenium hystrophorus L.,weed.**

1. INTRODUCTION

Parthenium weed is an annual herb in the family Asteraceae which is characterized by deep tap root,pale green leaves and an erect stem that becomes woody gradually (Jemal and Behailu,2016).At maturity,the plant develops several branches in its top half and may finally reach a height of 1.5-2 meters (EPPO,2014).It is originated in northern Mexico and southern USA,and spreading in more than 20 countries of Africa,Asia and Oceania(Dhileepan and Strathie,2009;EPPO,2014).

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Parthenium was probably introduced to Ethiopia through army vehicle during 1976 Ethio-Somalian war or along with contaminated grain in the course of food aid (Tamado and Milberg, 2000;kumar and Varshney, 2010).However,Wise *et al.*(2007) reported Parthenium was first recorded in Ethiopia at the Haramaya University campus in 1968. Since its introduction the weed has rapidly spread throughout agricultural lands,forests,orchards,poorly managed arable crop lands and rangelands in Ethiopia(Tamado and Milberg, 2000;Tefera,2002).

*Parthenium hystrophorus*L.is among the top five highly targeted weed in the weed management program of the Research Institutes and Ministry of Agriculture and Natural resourcesof Ethiopia (G/selase and Getu,2009).Ayele*et al*., (2014) reported that there have been no specific studies on the impact of Parthenium weed on the diversity and composition of the standing vegetation and the soil seed bank of rangelands in southeast Ethiopia.Similarly,despite rapid spread and the presence of dense colonies of *Parthenium hystrophorus*,very limited initiative has been taken to investigate the impacts of this noxious weed and still no visible large scale mapping and quantification of its distribution accomplished in Ethiopia.The farmers and agricultural experts even who do not know its impact on the eco-system,its way of distribution and management methods.Therefore,the objective of this review was to identify the distribution,impacts and beneficial effects as well as the possible management practices against *P.hystrophorus*.

2. THE BIOLOGY OF THE PLANT

2.1. Name of Parthenium

The genus name Parthenium is derived from the Latin word parthenice—a reference to the plant now known as *Tanacetumparthenium*(L.) Bernh.or "feverfew;"*hysterophorus*was derived from the Greek *hystera*(womb)and *phoros*(bearing) referring to the prolific seeding habit of the plant.It is commonly called as bitter weed,carrot weed,broom bush,and congress grass (India);whitetop,escobaramarga,and feverfew(Caribbean).False ragweed and ragweed Parthenium (USA).*Parthenium hysterophorus*L.(parthenium weed) is a member of the tribe Heliantheae of the family Asteraceaean extremely diverse family with a cosmopolitan distribution(Manpreet*et al*.,2014).

2.1.1 Morphology of the plant

*Parthenium hystrophorus*L. of the family Asteraceae (tribe:Heliantheae) is fast maturing, erect,and much branched annual or ephemeral herb.It shows two distinct phases in life:juvenile, rosette or the vegetative stage and adult, mature, or the reproductive stage. The juvenile stage exhibits a rosette with large, dark green, simple, radicle, and pinnatisect small leaves lacking flowering .The large lower leaves are spread on the ground likea carpet, without allowing any vegetation underneath it (Lakshmi and Srinivas,2007).The adult stage is erect, much branched with deep taproot system that reaches up to 2m in height .The stem is hairy,octangular, longitudinally grooved and becomes tough and woody as the plant matures into a hardy bush. Leaves are simple,alternate,pinnatelyor bipinnately dissected 20–30 x 12–25 cm becoming smaller towards the apex of the branches.The stem and leaf surface is covered with four types of glandular and non-glandular multicellular white trichomes.The flowers are creamy white, about 4mm across, arising from the leaf forks.Enormous number of pollen grains,624 millions/plant, are produced which are anemophilous that is wind pollinated.Each flower produces four to five black wedge shaped seeds that are 2mm long with thin white scales and difficult to see by the naked eye.It is a very prolific seed producer,producing up to 25,000 seeds/ plant, leading to large seed bank in the soil (Arshad and Tehmina,2006).

Figure 1: The vegetative and reproductive parts of Parthenium (Adapted fromManpreet*et al*.,2014)

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2.2 Ecology and distribution of Parthenium weed

Parthenium weed is counted as one of the most serious invasive alien plant on the planet earth, because of its potential for rapid distribution, its impact on ecosystem and socio- economy of the people(Asad and Steve,2011).So far it was not considered a weed of orchards and forests but now it has spread rapidly into these areas (Kumar, 2012); which propagates itself largely in forest due to the absence of weeding practices in such environments.

The invasion of *P.hystrophorus*L.weed was reported in forest and grazing lands with little or no growth of any other species which results threatening of local biodiversity(Kumar,2012). Parthenium weed has much more potential to invade bare lands like disturbed road sides and overgrazed pastures than dense pasture (Ayana *et al*.,2011);it also grows under grass land and crop field (Netsere and Mendesil,2011).

It has already become invasive in South Africa and Ethiopia, and appears to be extensively spreading in Uganda and Kenya.Parthenium weed has invaded more than 2 million ha of grazing and crop land, thus becoming a risk for the biodiversity,agriculture and human health in Ethiopia(Asad and Steve,2011).

*Parthenium hystrophorus*L.*was* widely distributed after its introduction in Ethiopia.Rate and extent of spread of this weed since its introduction has been more noticeable in Ethiopia and Swaziland than Kenya, South Africa and Zimbabwe although environmental conditions are also suitable in the latter countries.Higher distribution in Ethiopia and Swaziland could be due to higher levels of disturbance (e.g. overgrazing) and particular land use practices.

Figure 2: Parthenium infestation near forest land at Maddawalabu district, Bale Zone (Photo by Jemal,2016)

Parthenium hystrophorus L. is spreading rapidly in various rangeland areas and farm lands of Gambella,Oromia,Afar,Amhara and Somali national regional states which affecting crop production severely.Hadas and Taye(2015) reported its distribution in to Tigray region particularly,Waja,Alamta town,Bala,kukufto,Zata,Weyrawiha, Bedenoleka, Mohonitown, Maichew town, KisadGudo,Adishu,Adigura and Adigudom).It is found in all the Districts but more prominent in Alamata and Raya Azebo.According to the study conducted by Taye (2007)extensive infestation in the central farmlands of east Shewa,Dukem, Bishoftu, Modjo andKoka areas has been prevailed.Gebrehiwot and Berhanu (2015) reported that there has been an urgent need towards the management of Parthenium weed in Arba Minch, before it further spread to NechSar National Park, which is a home of plants' diversity.Zuber*iet al*.(2014) informed that *P.hystrophorus* is spreading rapidly in the highlands of Ethiopia.

The distribution and spread of Parthenium showed that it was not only restricted to the infested Districts but also spread to non-infested Districts like Arero,Bore,Dama and Uraga Districts of Borana and Guji Zones.It is found in Abaya occasionally, present in BuleHora,abundant in DugdaDawa,very abundant in Yabello, present in Teltele, frequent in Dire on roadsides, present in Miyo and Moyale, very abundant in Liben, present in Wadera, Adola and Shakiso districts (Berhanu*et al*.,2015).Parthenium is widely spread in the range lands and in the cultivable fields of East Showa Zone of Boset district (Belachew and Tessema, 2015).

2.2.1 Causes of distribution

The domination and rapid spread of *P. hystrophorus*L.in grazing lands with gradual reduction of native plant species could be due to its high invasive capacity, allelopathic properties, short life cycle and prolific character (Dalip*et al*., 2013**).**The species prefers neutral to alkaline pH soils, but tolerates a wide variety of soil types. *P. hystrophorus*L.is best suited to areas with an annual summer rainfall greater than 500 mm (Chamberlain and Gittens, 2004). Seeds of parthenium can germinate during any season of the year if the moisture is available. It can keep its viability for a long period of time and can grow under very harsh environmental condition (Williams and Groves, 1980) and at any climatic condition and environment (Netsere and Mendesil, 2011). Tamado*et al.* (2002) has pointed out that there are no observable climatic conditions that may limit the germination of *P.hystrophorus*L.in Ethiopia, with exception of high moisture requirement during germination. Such that the only major factor that can limit its germination could be moisture stress during the dry season.However,Ayana *et al*.(2011) concluded that Parthenium weed has the ability to utilize the opportunity of drought prone period in the area to use the chance where the indigenous plants deteriorate and leave much bare ground cover.

Parthenium produced numerous seeds, maturity, large quantities of seed production (up to 25,000), easily transported by vehicles,machinery,animals,fodder,pasture seed, stock feed and water.As Parthenium weed does not reproduce vegetative from plant parts, the only method of reproduction and spread is by seed.Large colonies along waterways and drainage floodplains indicate its movement in sheet water.In addition,most long-distance dispersal of seed is by vehicles and farm machinery,as evidenced by the major spread of Parthenium along roads. A period of drought followed by rain provides suitable environmental conditions for spread. Drought reduces pasture cover (competition) and increased movement of stock and stock fodder also aids the spread of seed.In particular,flooding after drought is advantageous to the weed,as flood is a dispersal mechanism for Parthenium seed.However,seed spread by wind is limited (Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers, 2001).Parthenium hystrophorus is not edible for animals and this could also be another opportunity for its distribution(Hailu,2010).Hina and Tahira (2009) suggested that in addition to its capability to withstand wide climatic ranges the weed is germinates and grow in all seasons.The seeds of Parthenium germinate in the hottest month of June (mean maximum 38.7ºC) and flourish by producing flowers, fruits and shedding seeds in the coldest months of December and January, when the mean minimum temperature is 3.4 and 2.6 °C respectively.

2.2.2 Habitat

Parthenium grows widely in wastelands,public lawns,orchards,forestlands,flood plains, agricultural areas urban areas,overgrazed pastures,industrial areas,playgrounds,roadsides, railway tracks,and residential plots.Drought and subsequent reduced pasture cover create the ideal situation for the Parthenium weed to establish itself.Although Parthenium weed is capable of growing inmost soil types, it is most dominant in alkaline clay loam soils.

2.2.3 Seed dispersal and germination of seeds

The seeds are mainly dispersed through water currents, animal's movement, vehicles, machinery, grains, stock feed and to a lesser extent by the wind. Most of the long distance spread is through vehicles, farm machinery and flooding.The spread of seeds plus their ability to remain viable in the soil for many years pose one of the most complex problems for control (Monaco*et al*.,2001).Seeds do not have a dormancy period and are capable of germinating anytime when moisture is available.Seeds germinate within a week with the onset of monsoon and flowering starts after a month and continues up to another three months.In northwest India, Parthenium germinates mainly in the months of February-March,attaining peak growth after rains in June-July and produces seeds in September-October.It normally completes its life cycle within 180–240 days.Its growth remains less and stunted from November to January due to severe cold.

3. HARMFUL EFFECTS ON ECOLOGY AND HEALTH

3.1. Impact of *Parthenium hystrophorus* L.on biodiversity

Parthenium is considered as the number one dangerous terrestrial weed because of its harmful effects both to human's health, animal production and biodiversity.Globally, several studies revealed the aggressiveness of Parthenium in the

ecosystem.The report of Dalip*et al*.(2013**)** from Mehari Sub-Watershed of Rajouri Forest Range, India, indicated that Parthenium weed occupy new surroundings and often substitute the native plant species, resulting in a serious damage to biodiversity.A study by Ayana *et al*.(2011) in Awash National Park (Ethiopia) showed that Parthenium weed, within a few years from its introduction into Awash National Park,caused a decline (average 69%) in stand density of herbaceous species. Similarly,Asresie (2008) pointed out that an increase in the level of Parthenium infestation causing rapid decline in the population and diversity of species in the ecosystem.

Figure 3: Effect of Parthenium on biodiversity (Photo by Jemal,2016)

3.2. Effects of *Parthenium hystrophorus*L.on crop production

The impact of Parthenium on the yield losses of various crops and orchards has been addressed in the report of earlier works.Crop losses are caused mainly due to allopathic effects and its ability to compete for common resources like nutrients and moisture and its competitive nature is relatively very much higher than expected from a similar crop weed.Another mechanism by which Parthenium affect crop productivity is through its ability to cover crops in pollen, which prevents seed set with resulting losses in yields of up to 40% (Wise *et al*.,2007).

Parthenium weed can infest the land where cereals, vegetables and horticultural crops found and reduce agricultural productivity due to its allelopathic effect (Mulatu*et al*.,2009).The decline in yield due to its highly competitive ability was also reported by Netsere and Mendesil(2011). Tamado*et al*.(2002) reported that if P.hystrophorus is not weeded throughout the season the yield of sorghum bicolor can be reduced in the range of 40% and 90% in Ethiopia,this percentage was closer to the report of Wise *et al*.(2007),which was range from 45-80%. According to Nganthoi*et al*.(2014) there was a visible impact on the growth parameters, yield and yield components of Zeamays by Parthenium. Accordingly, at high ratio (20:1) population of Parthenium the plant height, dry biomass, corn weight, corn length and grain weight per corn were reduced to 21.1%, 42.3%, 50.9%, 51.2%, and 52.7% respectively as compared to control. Furthermore, the finding indicate Parthenium in the form of extract or residue or growing weed can affect the germination and growth by reducing radicle and plumule length of Zea mays. Tefera (2002) also reported that 10% leaf aqueous extract of Parthenium hystrophorus resulted in total failure of seed germination in *Eragostistef*. Similarly, Demissie*et al*. (2013) found the presence of allelopathic effect in Parthenium extracts which could affect the seed germination and elongation of Onion and Bean. Dangwal*et al*. (2010) investigated that while primary major essential nutrients (NPK fertilizer) supplied, but in the absence of herbicide application and mechanical weeding, Parthenium weed along with other weeds were reduced the yield of wheat by 25.35%. Besides reducing the yield they also reduce the quality of germplasm of wheat crop. Raj and Jha (2016) disclosed that higher concentrations of leaf extract have irregularly affected the growth of *Phaseolusmungo* than lower concentrations.

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Figure 4:The impact of Parthenium on crop production (photo by Wondi,2014)

3.3. Effects ofParthenium on animal production and human health

Toxic substances found in Parthenium are lethal to human beings and animals (Singh *etal*., 2002).It is considered to be a cause of allergic respiratory problems,contact dermatitis, mutagenicity in human and livestock.In addition,by reducing the species bio diversity it affect the productivity of grazing land and hence reduce feed supply for animals.It releases chemicals that inhibit the germination and growth of pasture grasses and other plants (Dalip*et al*.,2013).If Parthenium is eaten by animals,the meat gets polluted due to its toxicity problem and these result indirect economic losses.Thus, domestic animals should avoid eating it (Wise *et al*.,2007).

When human beings come in contact with this weed, it may cause allergy,dermatitis,eczema, black spots and blisters around eyes,burning rings and blisters over skin, redness of skin and asthma (Handa*et al*.,2001).Parthenium is spreading at alarming rate,threatening agricultural ecosystem,biodiversity,human and animal health in Ethiopia.The response of the 64 interviewed farmers in Ethiopia showed that all of them have health problems in different nuances. Most frequently they responded to Parthenium contact with light allergic symptoms like hay fever or skin prickle on arms and hands. Some farmers had worse health problems: cracks on hand balms, fever, prickle on the whole body,skin irritations and asthma.In addition to parthenin high concentrations of phenolic acids which might also contribute to health problems (Ulrichs*et al.*, 2007).Studies in Jijiga (Ethiopia) indicated that *Parthenium* causes asthma,bronchitis,dermatitis, and high fever in human (Shashie, 2007).

Parthenium weed is toxic to animals causing dermatitis with pronounced skin lesions on various animals including horses and cattle.If eaten,it is responsible for mouth ulcers with excessive salivation. Significant amount (10–50%) of this weed in the diet can kill cattle. In addition,it causes anorexia, pruritus, alopecia, diarrhea and eye irritation in dogs. It also causes acuteillness when bitter milk and tainted meat from buffaloes,cows and goats are fed on grass mixed with Parthenium.The Parthenium extract results in significant reduction of rat WBC count which signifies its immune system weakening ability.

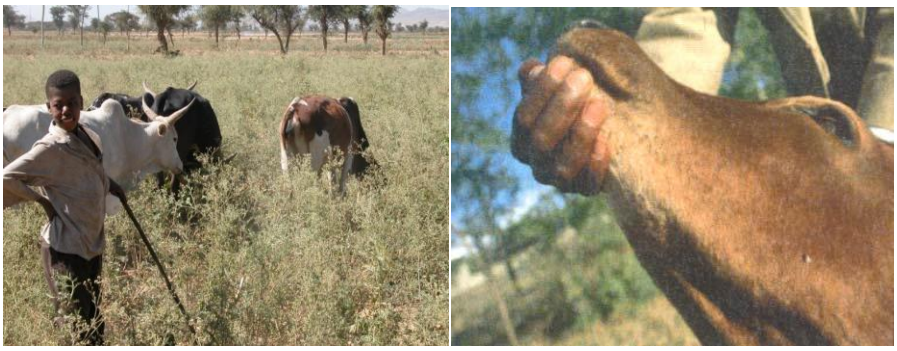

Figure 5: The effect of Parthenium on animal production(photo by Wondi,2014)

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The pollen grains, air borne dried plant parts, and roots of Parthenium cause various allergies like contact dermatitis,hay fever,asthma,and bronchitis in human beings.The common allergens found in this weed are parthenin,coronopilin,tetraneuris,and ambrosin.Pollens of Parthenium cause asthma(allergicbronchitis),especially in children playing outdoors and in adults and old age persons. Contact of plant with the body causes dermatitis and the spread of the problem all over the body causes great discomfort (M. Wiesner and T. Tessema, 2007).

Figure 6:The effects of *P.hystrophorus* on human health lesions on skinoverdorsalhands (Adapted fromManpreet*et al.*,2014)

Parthenin has been reported as a germination and radical growth inhibitor in a variety of dicot and monocotplants.The weed affects nodulation in legumes due to inhibition of activity of nitrogen fixing and nitrifying bacteria, namely rhizobium, Actinomycetes,Azotobacter and Azospirillum.Parthenium produces enormous numbers of pollens (on an average 624 million/plant)which are carried away at least to short distance in clusters of 600–800 grains, and settles on the vegetative and floral parts, including stigmatic surface,inhibiting fruit setting in crops like tomato, brinjal, beans and capsicum.

4. CONTROL AND MANAGEMENTOPTIONS

4.1. Physical control and mechanical control

Control operations should focus on preventing spread, the eradication of small and isolated populations (Wise *et al*.,2007).Khan *et al.*, (2013) reported that manual weeding and tillage are the most common control practices used to control Parthenium weed. According to van der Laan (2006) manual removal of P. hystrophorus is often not cost-effective and therefore used on a limited basis.Hand-pulling should ensure the removal of the entire crown to prevent regeneration from remaining lateral shoots.Correspondingly,Patel(2011)stated that manual uprooting of Parthenium before flowering and seed setting is the most effective method. This is easily done when the soil is wet. Uprooting the weed after seed setting will increase the area of infestation. Pulling a plant in flower will aid in the dispersal of pollen grains, resulting in allergic reactions. Mulching with *Gliricidiasepium*, or any other suitable and acost-effective mulch, coupled with manual weeding before land preparation would help suppressing the growth and development of the Parthenium weed and enhance yield of tomato (Nishanthan*et al*,2013). However, burning of *P. hystrophorus*should be avoided in the agricultural field to enhance overall productivity(Kumar,2010).This could be due to the fact that burning requires large quantity of fuel. Moreover, burning destroys all plants and predators in vicinity.

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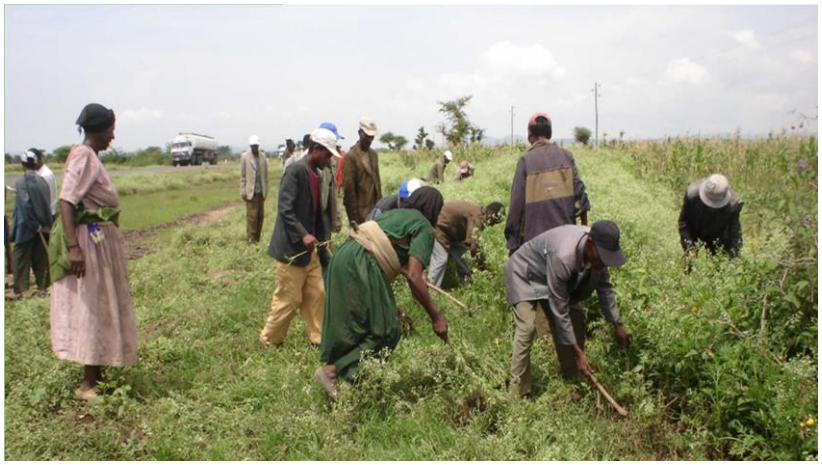

Figure7: Physical and mechanical control of Parthenium weed in Ethiopia(photo by Wondi,2014)

4.2. Chemical control

Effective herbicides are registered for use against Parthenium but chemical control requires repeated, regular follow-up treatments (Lorraine and Lin,2015).Generally,Parthenium plants can effectively be controlled with glyphosate tank mixed with low concentrations of urea and common salt **(**Zelalem,2013).Thus,treating 3000 ml of glyphosate with 150 ml of urea and 150 ml of common salt solutions and spraying at 6 to 8 leave stage resulted in complete mortality of Parthenium weed in short period of time by increasing the phytotoxicity of this herbicide. While spraying this solution at 50 and 75% flowering stages showed poor mortality rates on this weed. The growth of Parthenium can be suppressed using amino acid synthesis and photosynthesis inhibitors as compared to herbicides with other modes of action. In wasteland, non-cropped areas, along railway tracks, water channels and roadsides, the use of glyphosate and metribuzin has been shown promising results.On the other hand,the treatment should be accomplished at rosette stage to be effective.Parthenium weed control at rosette stage is highest with glyphosate (96%) followed by metribuzin 87% at 4 weeks after treatment (WAT) and control is lowest with pendimethalin (42.5%) at 4 WAT.Thus,glyphosate and metribuzin are recommended for the control of Parthenium weed in non-cropped areas (Haroon*et al.*, 2012).Bactril Super @ 0.67 ml/L water can control Parthenium.However, huge amount of Parthenium plants cannot be controlled economically by chemicals (Rezaul,2012). Reddy *et al.* (2007)suggested that Norflurazon,Clomazone,Fluometuron,Flumioxazin,Halosulfuron, Chlorimuronand Trifloxysulfuron could provide effective control of Parthenium.Fernandez (2013) has shown that under field condition, Saflufenacil + dimethenamid-P and hexazinone were highly effective and rapid in controlling flowering parthenium, providing 100% control at all evaluation timings (3, 6, 9 weeks after treatment).While in greenhouse, aminocyclopyrachlor + chlorsulfuron, aminopyralid, hexazinone, saflufenacil + dimethenamid-P, 2,4 D provided 100% aboveground dry weight reduction of rosette parthenium at 21 DAT.

4.3. Biological control.

Biological control can play a significant role to check the growth of Parthenium weed because it would be more sustainable and possibly cost effective (Evans,1997;Lorraine and Lin,2015). Several effective biological control agents are already available and can be introduced and released with a minimum of additional research required. Six potential agents have been released for biological control, mainly in Australia.

The two most important species that have been established in Ethiopia are *Zygogrammabicolorata*(leaf feeding beetle) and *Listronatussessitopennis*(stem galling moth) and they have a significant impact on Parthenium in Ethiopia.*Z.bicolorata*was released in Ethiopia where it caused widespread defoliation,permitting local vegetation to grow again(Wondi,2014). In Australia,*E.strenuana*can exert significant control but erratic rainfall has disrupted the moth populations, reducing them to very low levels. Populations take a long time to build-up again, usually too late to have a significant impact on the weed (Wise *et al.*, 2007). According to Kumar *et al.*(2009)Cladosporium sp.(MCPL-461) affects the embryo development which enhances the sterile seeds formation.Spraying of this sp. has deleterious effects on Parthenium weed only not to other plant specieswhich living together under same niche.Due to invasive nature and luxuriant growth capacity of Parthenium in different habitat, Cladosporium sp. as a floral and leaf pathogen may be used

as a potential myco-herbicide against this weed. Rezaul(2012) reported that *Pucciniaabrupta*is appropriate disease that used to control Parthenium. Finally, biological control using natural enemies from the plant in its native range would be the most sustainable management intervention and requires further research.

Figure 8: *Zygogrammabicolorata*larva feeding on leaf and *Listronatussetosipennis*stem boring beetle of parthenium weed at Ambo plant protection center,Ethiopia(photo by Wondi,2014)

4.4.Botanical control methods

Aqueous and methanol extracts of *Nerium oleander*L.leaves inhibited seed germination (Germination percentage,germination speed, germination value and peak value) and early growth (root hair formation,root and shoot lengths of seedlings) of *P.hystrophorus*L. in a concentration dependent manner.Methanol extracts of white flowered variety showed higher inhibition compared to that of pink flowered variety (at 1:40 dilution of the stock,inhibition was 60% and 23.4% with white and pink respectively (Rajyalakshmi*et al*.,2011).Belachew and Tesema (2015) assessed the weed flora composition in Parthenium (*P.hystrophorus*L.) infested area of East Shewa Zone,Ethiopia and finally investigated three herbaceous species,namely *Cassia tora,Xanthiumstrumarium*and *Argemonemexicana*which had good association and grow with *P.hystrophorus*in competition and these species are recommended for *Parthenium* eradication.According to Lorraine and Lin (2015) reducing livestock densities to increase grass cover assists to alleviate Parthenium infestations. Root and shoot extracts of the three allelopathic grasses viz.,*Dicanthiumannulatum*Stapf.,*Cenchruspennisetiformis* Hochest and *Sorghum halepense*Pers.,reduced germination and suppressed early seedling growth of exotic weed *P.hystrophorus* L.Aqueous extracts of *D. annulatum* and *C.pennisetiformis* were more inhibitory than extracts of *S. halepense*.The highest suppressive ability was exhibited by extracts of *C.pennisetiformis* where 20% shoot and 25% root extract completely inhibited the germination of *P. hystrophorus*.Arshadand Tehmina(2006)pointed out that shoot extracts were moreinhibitory than the root extracts.In a phytochemical control study,*Cassia occidentals,Rumexdentatus, Calotropisprocera and Withaniasomnifera*had been evaluated for their herbicidal potential against biochemical activities and mortality percentage of Parthenium. The study concluded that the 100%, 9th day aqueous shoot leachates of *C.occidentals*found effective in arresting germination and suppressing seedling growth of Parthenium (Jai *et al*.,2010).Sing *et al*.(2013) studied the effect of leachates of different phonological stages of *C.occidentals*L.on *P.hystrophorus*L.Accordingly,100% concentration of leaf leachate from vegetative stage completely inhibited the germination while highest concentration of leaf leachate from vegetative,flowering, fruiting and fruit ripening stages caused the death of the plants.

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5. CONCLUSION AND FUTURE DIRECTIONS

Parthenium one of the major invasive weed species belongs to family Asteraceae which is characterized by deep tap root,pale green leaves and an erect stem.Parthenium was introduced to Ethiopia through army vehicle during Ethio-Somalian war or along with contaminated grain in the course of food aid.Parthenium was first recorded in Eastern part of Ethiopia at the Haramaya University and distributed to wide geographical regions of the country.The distribution of *Parthenium hystrophorus*L.weed in various environments including crop lands,range lands,road sides,forests,watersheds and other economically important ecosystems has been identified.Its dissemination is at an alarming rate which gives the impression of difficulty to control its distribution in the future.

The noxious *P.hystrophorus* grows in diverse habitatsin below ground soil nutrients.It is capable of competing native and non-native palatable plants that are important to livestock.Furthermore,the changes in vegetation and soil nutrients could lead to ultimate changes in other trophic levels and alter the function of the ecosystem.Appropriate methods for the management of *P.hystrophorus*are necessary to avoid potential threats to biodiversity and economic losses.The efficient and environment-friendly alternative is essential than other and toxic.physical methodtime-consuming,costly and chemical method is toxic to environment.The use of botanical control through allelopathy,insects and fungal pathogens are methods of control. Therefore,Sustainable management practices are needed to reduce the losses and risks due to weed.To realize this,the first step is to make the farmer aware of the biology of the weed and the means of its dissemination.On farm research and extension practices should incorporate farmers, in order to assess whether the introducedmanagement method is too technical or easy to adopt. In addition to this,extension and quarantine facilities should be collaborated with the appropriate subject matter specialists to prevent the introduction of the weed frombeing introduced to un-infested areas.Search for improved or alternative approaches should be facilitated by,increased understanding of the complex ecological and physiological interactions between parasitic plants andtheir hosts.Similarly,environmental impact assessment of the introduced practices should be assessed in order to develop ecologically justifiable control strategies.

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